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Table 68.304(a)

Voltage Applied for Various Combinations Of Electrical Connections

Voltage source connected between:	*ac Value**
(a) and (b) (see NOTES 1, 2, 3)	*1500*
(a) and (c) (see NOTES 1, 2)	*1000*
(a) and (d) (see NOTES 1, 2)	*1000*
(a) and (e) (see NOTES 1, 2)	*1000*
(a) and (f) (see NOTES 1, 2)	*1000*
(a) and (g) (see NOTES 1,2)	*1000*
(b) and (c) (see NOTE 3)	*1500*
(b) and (d) (see NOTE 3)	*1500*
(b) and (e) (see NOTE 3)	*1500*
(b) and (f) (see NOTE 3)	*1500*
(b) and (g) (see NOTE 3)	*1500*
(c) and (e) (see NOTES 1, 2)	1000
(c) and (f) (see NOTES 1, 2)	1000
(d) and (e) (see NOTE 2)	1000
(d) and (f) (see NOTE 2)	1000
(e) and (f) (see NOTE 2)	1000

*Value to which test voltage is gradually increased.

NOTES:

(1) A telephone connection, auxiliary lead, or E&M lead that has an intentional dc conducting path to earth ground at operational voltages (such as a ground start lead), may be excluded from the leakage current test in that operational state. Leads or connections excluded for this reason shall comply with the requirements of § 68.306(e)(1).

A telephone connection, auxiliary lead, or E&M lead that has an intentional dc conducting path to earth ground for protection purposes at the leakage current test voltage (such as through a surge suppressor), may have the component

providing the conducting path removed from the equipment for the leakage current test in that operational state. Components removed for this reason shall comply with the requirements of § 68.306(e)(2).

Filter paths, such as capacitors used in EMI filters, are left in place during leakage current testing, since these components can be a path for excessive leakage.

(2) For multi-unit equipment interconnected by cables, that is evaluated and registered as an interconnected combination or assembly, the specified 10 mA peak maximum leakage current limitation other than between power connection points and other points, may be increased as described here to accommodate cable capacitance. The leakage current limitation may be increased to (10N+0.13L) mA peak where L is the length of interconnecting cable in the leakage path in meters and N is the number of equipment units that the combination or assembly will place in parallel across a telephone connection.

(3) RF filters and surge protectors on the line side of power supplies may be disconnected before making § 68.304 leakage measurements. As an alternative to disconnecting these filters and surge protectors, this measurement may be made using a dc voltage equal to the peak ac test voltage.

7. Section 68.306 is revised to read as follows:

§ 68.306 Hazardous voltage limitations.

(a) General. Under no condition of failure of registered terminal equipment or registered protective circuitry that can be conceived to occur in the handling, operation or repair of such equipment or circuitry, shall the open circuit voltage on telephone connections exceed 70 volts peak after one second, except for voltages for network control signalling, alerting and supervision.

(1) Type I E&M Leads. Registered terminal equipment shall comply with the following requirements for terminal equipment on the "A" or "B" side of the interface as shown in Figures 68.3(e)(I) & (ii):

(i) The dc current on the E lead shall not exceed 100 mA.

(ii) The maximum dc potentials to ground shall not exceed the following when measured across a resistor of 20 kohms ± 10 %.

Table 68.306(a)

Type I E&M
DC Potentials

	E Lead	M Lead
TE on "B" side originates signals to network on E lead	± 5 V	±5 V
TE on "A" side originates signals to network on M lead	-56.5V; no positive potential with respect to ground	-56.5V; no positive potential with respect to ground

(iii) The maximum ac potential between E&M leads and ground reference shall not exceed 5V peak.

(iv) M lead protection shall be provided to that voltages to ground do not exceed 60 volts. For relay contact implementation, a power dissipation capability of 0.5 watt shall be provided in the shunt path.

(v) If the registered terminal equipment contains an inductive component in the E lead, it must assure that the transient voltage across the contact as a result of a relay contact opening does not exceed the following voltage and duration limitations:

(A) 300 volts peak,

(B) A rate of change of one volt per microsecond, and

(C) A 60-volt level after 20 milliseconds

(2) Type II E&M Leads. Registered terminal equipment shall comply with the following requirements:

(i) For terminal equipment on the "A" side of the interface, the dc current in the

E lead shall not exceed 100 mA. The maximum ac potential between the E lead and ground shall not exceed 5 V peak.

(ii) For terminal equipment on the "B" side of the interface, the dc current in the SB lead shall not exceed 100 mA. The maximum ac potential between the SB lead and ground shall not exceed 5 V peak.

(iii) The maximum dc potentials to ground shall not exceed the following when measured across a resistor of 20 kohms ± 10 %.

Table 68.306(b)

Type II E&M
DC Potentials

	E lead	M lead	SB lead	SG lead
TE on "B" side of the interface originates signals to network on E lead	±5 V	±5 V	-56.5V; no positive potential with respect to ground	±5 V
TE on "A" side of the interface originates signals to network on M lead	-56.5V; no positive potential with respect to ground	±5 V	±5 V	±5 V

(iv) The maximum ac potential to ground shall not exceed 5V peak on the following leads, from sources in the terminal equipment:

(A) M, SG and SB leads for terminal equipment on the "A" side of the interface.

(B) E, SG and M leads for terminal equipment on the "B" side of the interface.

(v) If the registered terminal equipment contains an inductive component in the (E) or (M) lead, it must assure that the transient voltage across the contact as a result of a relay contact opening does not exceed the following voltage and duration limitations:

(A) 300 volts peak,

(B) A rate of change of one volt per microsecond, and

(C) A 60-volt level after 20 milliseconds

(3) *Off premises station voltages.*

(A) Talking battery or voltages applied by the PBX (or similar systems) to all classes of OPS interface leads for supervisory purposes must be negative with respect to ground, shall not be more than -56.5 volts dc with respect to ground, and shall not have a significant ac component.*

*The ac component should not exceed 5 volts peak, when not otherwise controlled by § 68.308.

(ii) Ringing signals applied by the PBX (or similar systems) to all classes of OPS interface leads shall comply with requirements in paragraph (d) of this section. Ringing voltages shall be applied between the ring conductor and ground.

(4) Direct Inward Dialing (DID).

Voltages applied by the PBX (or similar systems) to DID interface leads for supervisory purposes must be negative with respect to ground, shall not be more than -56.5 volts dc with respect to ground, and shall not have a significant ac component.*

*The ac component shall not exceed 5 volts peak, where not otherwise controlled by § 68.308.

(5) Local Area Data Channel Interfaces. For Local Area Data Channel interfaces, during normal operating modes including terminal equipment initiated maintenance signals, registered terminal equipment shall ensure, except during the application of ringing (limitations specified in paragraph (d) of this section), with respect to telephone connections (tip, ring, tip 1, ring 1) that:

(i) Under normal operating conditions, the rms current per conductor between short-circuit conductors, including dc and ac components, does not exceed 350 milliamperes. For other than normal operating conditions, the rms current between any conductor and ground or between short-circuited conductors, including dc and ac components, may exceed 350 milliamperes for no more than 1.5 minutes;

(ii) The dc voltage between any conductor and ground does not exceed 60 volts. Under normal operating conditions it shall not be positive with respect to ground (though positive voltages up to 60 volts may be allowed during brief maintenance states);

(iii) Ac voltages are less than 42.4 volts peak between any conductor and ground, (terminal equipment shall comply while other interface leads are both

(A) unterminated, and

(B) individually terminated to ground); and,

(iv) Combined ac and dc voltages between any conductor and ground are less than 42.4 volt peak when the absolute value of the dc component is less than 21.2 volts, and less than (32.8 + 0.454 x Vdc) when the absolute value of the dc component is between 21.2 and 60 volts.

(6) *Ringdown Voiceband Private Line and Voiceband Metallic Channel Interface.* During normal operation, registered terminal equipment for connection to ringdown voiceband private line interfaces or voiceband metallic channel interfaces shall ensure that:

(i) Ringing voltage does not exceed the voltage and current limits specified in paragraph (d), and is:

(A) applied to the ring conductor with the tip conductor grounded for 2-wire interfaces, or

(B) simplexed on the tip and ring conductors with ground simplexed on the tip 1 and ring 1 conductors for 4-wire interfaces.

(ii) Except during the signaling mode or for monitoring voltage, there is no significant positive dc voltage (not over +5 volts) with respect to ground:

(A) for 2-wire ports between the tip lead and ground and the ring lead and ground and

(B) for 4-wire ports between the tip lead and ground, the ring lead and ground, the tip 1 lead and ground, and the ring 1 lead and ground.

(iii) The dc current per lead, under short circuit conditions shall not exceed 140 milliamperes.

(b) Connection of non-registered equipment to registered terminal equipment or registered protective circuitry. General. Leads to, or any elements having a conducting path to telephone connections, auxiliary leads or E&M leads shall:

(i) Be reasonably physically separated and restrained from and be neither routed in the same cable as nor use the same connector as leads or metallic paths connecting power connections;

(ii) Be reasonably physically separated and restrained from and be neither routed in the same cable as nor use adjacent pins on the same connector as metallic paths to lead to nonregistered equipment, when specification details provided to the Commission, pursuant to, § 68.200(g), do not show that interface voltages are less than non-hazardous voltage source limits in para. 68.306(c) of this section.

(c) *Non-Hazardous Voltage Source.* A voltage source is considered a non-hazardous voltage source if it conforms with the requirements of § 68.302, § 68.304 and para. (b) of this section, with all connections to the source other than primary power connections treated as "telephone connections," and if such source supplies voltages no greater than the following under all modes of operation and of failure:

(1) AC voltages less than 42.4 volts peak;

(2) DC voltages less than 60 volts; and

(3) Combined ac and dc voltages less than 42.4 volts peak when the absolute value of the dc component is less than 21.2 volts and less than (32.8 + 0.454 x V dc) when the absolute value of the dc component is between 21.2 and 60 volts.

(d) Ringing Sources. Except for class A OPS interfaces, ringing sources shall meet all of the following restrictions:

(1) Ringing Signal Frequency. The ringing signal shall use only frequencies whose fundamental component is equal to or below 70 Hz.

(2) Ringing Signal Voltage. The ringing voltage shall be less than 300 V peak-to-peak and less than 200 V peak-to-ground across a resistive termination of at least 1 megohm.

(3) Ringing Signal Interruption Rate. The ringing voltage shall be interrupted to create quiet intervals of at least one second (continuous) duration each separated by no more than 5 seconds. During the quiet intervals, the voltage to ground shall not exceed the voltage limits given in para. (a)(3)(i) of this section.

(4) Ringing Signal Sources. Ringing voltage sources shall comply with the following requirements:

(i) If the ringing current through a 500 ohm(s) (and greater) resistor does not exceed 100 mA peak-to-peak, neither a ring trip device nor a monitoring voltage are required.

(ii) If the ringing current through a 1500 ohm (and greater) resistor exceeds 100 mA peak-to-peak, the ringing source shall include a current-sensitive ring trip device in series with the ring lead that will trip ringing as specified in Figure 68.306(a) in accordance with the following conditions

(A) If the ring trip device operates as specified in Figure 68.306(a) with R = 500 ohm (and greater) no monitoring voltage is required;

(B) If, however, the ring trip device only operates as specified in Figure 68.306(a) with R = 1500 ohm (and greater) then the ringing voltage source shall also provide a monitoring voltage between 19 V dc and 56.5 V dc, negative with respect to ground, on the tip or ring conductor.

(iii) If the ringing current through a 500-ohm (and greater) resistor exceeds 100 mA (peak-to-peak) but does not exceed 100 mA peak-to-peak with 1500-ohm (and greater) termination, the ringing voltage source shall include either a ring trip device that meets the operating characteristics specified in Figure 68.306(a) with 500-ohm (and greater) resistor, or a monitoring voltage as specified in (d)(4)(ii)(B) above.

NOTE: If the operating characteristics specified in Figure 68.306(a) are not met with both the 500-ohm and 1500-ohm terminations, then the terminal equipment under test fails (See Table 68.306(c)).

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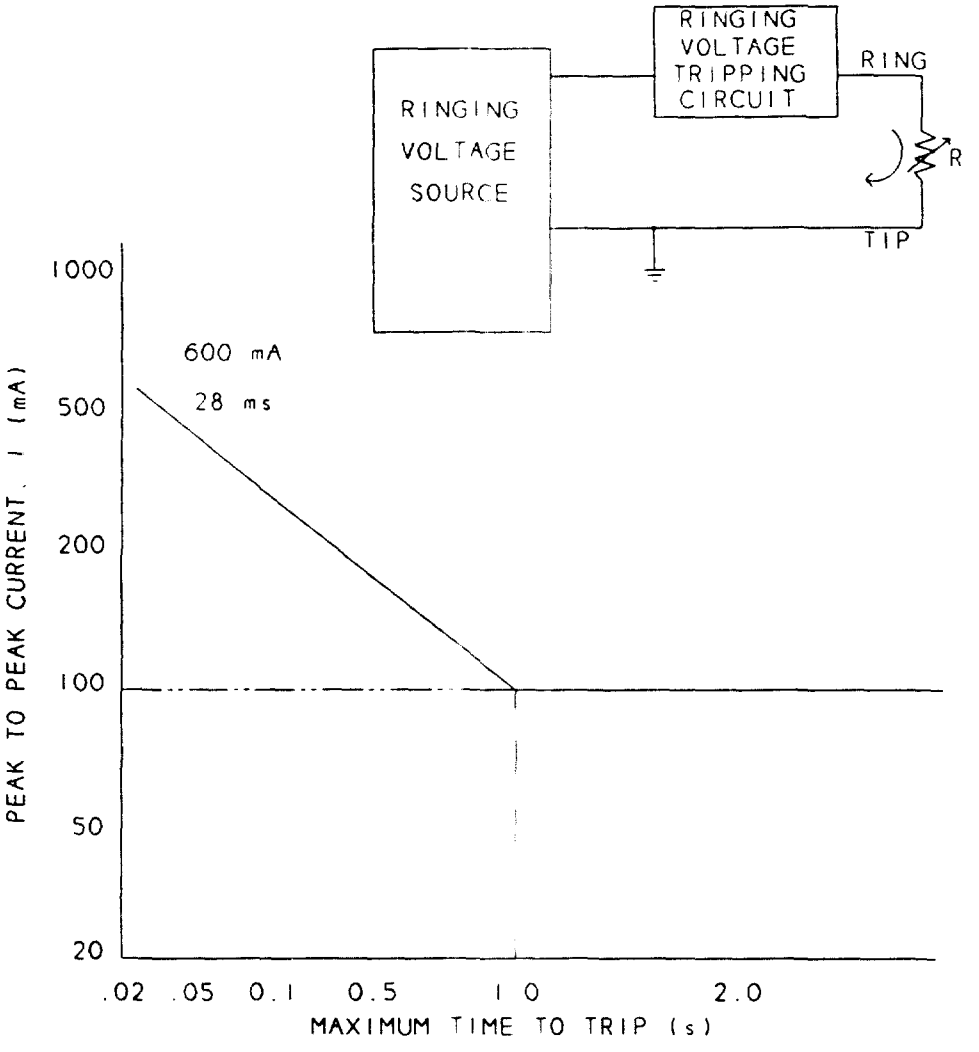
RINGING VOLTAGE TRIPPING CIRCUIT
RING
RINGING VOLTAGE SOURCE
R
TIP
1000
600 mA
28 ms
500
200
100
50
20
PEAK TO PEAK CURRENT, I (mA)
.02 .05 0.1 0.5 1.0 2.0
MAXIMUM TIME TO TRIP (s)

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Table 68.306(C)

Summary of Ring Trip Requirements

Section 68.306 (d) (4).	Ringing Current (mA p.p)		Function Required		Ring Trip Device operates per Figure 68.306(a)
	R=500 ohms & Greater	R=1500 ohms & Greater	Ring Trip	Monitor Voltage	
(I)	< 100	< 100	Optional	Optional	Optional
(ii) (A)	N/A	> 100	Yes	Optional	Yes for both resistances
(ii) (B)	N/A	> 100	Yes	Yes	Yes for R=1500 ohms & greater No for R=500 ohms & greater
(iii)	> 100	< 100	Either Ring-Trip Device or Monitor Voltage required		Yes for R = 500 ohms & greater, if Ring Trip Device is used

(e) Intentional paths to ground (as required by § 68.304).

(1) Connections with operational paths to ground. Registered terminal equipment and registered protective circuitry having an intentional dc conducting path to earth ground at operational voltages that was excluded during the leakage current test of § 68.304 shall have a dc current source applied between the following points:

(i) Telephone connections, including tip, ring, tip 1, ring 1, E&M leads and

auxiliary leads, and

(ii) Earth grounding connections.

For each test point, gradually increase the current from zero to 1 ampere, then maintain the current for one minute. The voltage between (I) and (ii) shall not exceed 0.1 volt at any time.

NOTE: In the event there is a component or circuit in the path to ground, the requirement shall be met between the grounded side of the component or circuit and the earth grounding connection.

(2) *Connections with protection paths to ground.* Registered terminal equipment and protective circuitry having an intentional dc conducting path to earth ground for protection purposes at the leakage current test voltage that was removed during the leakage current test of § 68.304 shall, upon its replacement, have a 50 or 60 Hz voltage source applied between the following points:

NOTE: The path to ground is reestablished when the leads are replaced.

(i) Simplexed telephone connections, including tip and ring, tip 1 and ring 1, E&M leads and auxiliary leads, and

(ii) Earth grounding connections

Gradually increase the voltage from zero to 120 volts rms for registered terminal equipment, or 300 volts rms for protective circuitry, then maintain the voltage for one minute. The current between (I) and (ii) shall not exceed 10 mA peak at any time.

As an alternative to carrying out this test on the complete equipment or device, the test may be carried out separately on components, subassemblies, and simulated circuits, outside the unit, provided that the test results would be representative of the results of testing the complete unit.

8. Section 68.308 is revised to read as follows:

§ 68.308 Signal power limitations.

* * * * *

(a) *General.* Limits on signal power shall be met at the interface for all 2-wire

network ports and, where applicable to offered services, both transmit and receive pairs of all 4-wire network ports. Signal power measurements shall be made using terminations as specified in each of the following limitations. The transmit and receive pairs for 4-wire network ports shall be measured with the pair not under test connected to a termination equivalent to that specified for the pair under test. Through gain limitations apply only in the direction of transmission toward the network.

(b) *Voiceband metallic signal power.*

(1) Limitations at the interface on internal signal sources not intended for network control signaling:

(i) The power of all signal energy, in the 200 - 3995 Hz voiceband, delivered by registered terminal equipment or registered protective circuitry to the appropriate loop simulator – other than non-permissive data equipment or data protective circuitry shall not exceed -9 dBm when averaged over any 3 second interval.

(ii) For 2-wire and 4-wire lossless tie trunk type interfaces, the maximum power of other than live voice signals delivered to a 600-ohm termination shall not exceed -15 dBm when averaged over any three second interval.

(iii) For OPS lines, the maximum power of other than live voice delivered to an OPS line simulator circuit shall not exceed -9 dB with respect to one milliwatt, when averaged over any 3-second interval.

(iv) For registered test equipment or registered test circuitry the maximum signal power delivered to a loop simulator circuit shall not exceed 0 dBm when averaged over any 3-second interval.

(v) For voiceband private lines using ringdown or inband signaling the maximum power of other than live voice signals delivered to a 600 ohm termination shall not exceed -13 dBm when averaged over any 3-second interval.

(vi) For voiceband private lines using inband signaling in the band 2600 $\pm$ 150 Hz, the maximum power delivered to a 600 ohm termination shall not exceed -8 dBm during the signaling mode. The maximum power delivered to a 600 ohm termination in the on-hook steady state supervisory condition shall not exceed -20 dBm. The maximum power of other than live voice signals delivered to a 600 ohm termination during the non-signaling mode and for other inband systems shall not exceed -13 dBm when averaged over any 3-second interval

(2) *Limitations on internal signal sources primarily intended for network control signaling, contained in voice and data equipment.*

(i) For all operating conditions of registered terminal equipment and registered protective circuitry, the maximum power in the frequency band below 3995 Hz delivered to a loop simulator circuit shall not exceed the following when averaged over any 3-second interval:

(A) 0 dBm when used for network control (DTMF);

(B) 0 dBm when DTMF is used for manual entry end-to-end signaling. When the device is used for this purpose it shall not generate more than 40 DTMF digits per manual key stroke.

(C) -9 dBm in all other cases.

(ii) For tie trunk applications, the maximum power delivered to a 600 ohm termination for registered terminal equipment and registered protective circuitry under all operating conditions shall not exceed -4 dBm over any 3 second interval.

(3) Registered one port and multiport terminal equipment and protective circuitry with provision for through transmission from other terminal equipment, excluding data equipment and data protective circuitry that are registered in accordance with § 68.308(b)(4).

(i) Where through-transmission equipment provides a dc electrical signal to equipment connected therewith (e.g., for powering of electro-acoustic transducers), dc conditions shall be provided which fall within the range of conditions provided by a loop simulator circuit unless the combination of the through-transmission equipment and equipment connected therewith is registered as a combination which conforms to paras. (b)(1) and (2) of this section.

(ii) Through-transmission equipment to which remotely connected data terminal equipment may be connected shall not be equipped with or connected to either a Universal or Programmed Data Jack used in data configurations. (See paras. (b)(4) and (e) of this section).

(4) Registered data circuit terminal equipment shall be capable of operation in at least one of the states discussed in (i), (ii) or (iii). The output power level of the data circuit terminal equipment shall not be alterable, by the customer, to levels which

exceed the signal power limits specified herein.

(i) Data circuit terminal equipment intended to operate with a programming resistor for signal level control shall not exceed the programmed levels given in Table 68.308(a).

(ii) Data circuit terminal equipment intended to operate in the fixed loss loop (FLL) state shall not transmit signal power that exceeds -4 dBm, in the 200 - 3995 Hz voiceband, when averaged over any and all 3 second intervals.

(iii) Data circuit terminal equipment shall not transmit signals from 200 to 3995 Hz that exceed -9 dBm, when averaged over any and all 3 second intervals.

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Table 68.308(a)

Programming Resistor (R_P) (ohms)*	Programmed Data Equipment Signal Power Output
short	0 dBm
150	-1 dBm
336	-2 dBm
569	-3 dBm
866	-4 dBm
1240	-5 dBm
1780	-6 dBm
2520	-7 dBm
3610	-8 dBm
5490	-9 dBm

*Tolerance ± 1%

(5) *Registered one-port and multiport terminal equipment and protective circuitry with provision for through-transmission from ports to other equipment which is separately registered for the public switched network, or ports to other network interfaces.*

(i) Registered terminal equipment and registered protective circuitry shall have no adjustments that will allow net amplification to occur in either direction of transmission in the through-transmission path within the 200 - 3995 Hz voiceband that will exceed the following:

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Table 68.308(b) Allowable Net Amplification Between Ports (A)(C)(D)(E)

TO / FROM (E)	Tie Trunk Type Ports			Integrated Services Trunk	OPS Ports (2-Wire) (B)	Public Switched Network Ports (2-Wire)	HCC Digital PBX-CO 4-Wire
	2/4-Wire	Subrate 1.544 Mbps Satellite 4W	Subrate 1.544 Mbps Tandem 4W				
2/4-Wire Tie	0 dB	3 dB	3 dB	3 dB	6 dB	-	-
Subrate 1.544 Mbps Satellite 4W Tie	0 dB	-	3 dB	3 dB	6 dB	-	
Subrate 1 544 Mbps Tandem 4W Tie	-3 dB	0 dB	0 dB	0 dB	3 dB	-	-
Integrated Services Trunk	-3 dB	0 dB	0 dB	0 dB	3 dB	-	-
RTE Digital	0 dB	0 dB	0 dB	0 dB	3 dB	3 dB	0 dB
RTE (B) PSTN/OPS	-3 dB	-3 dB	-3 dB	- 3 dB	0 dB	0 dB	-3 dB
OPS (B) (2-Wire)	-2 dB	1 dB	1 dB	1 dB	4 dB	4 dB	1 dB
Public Switched Network (2-Wire)	-	-	-	-	3 dB	3 dB	-
HCC Digital PBX-CO (4-Wire)	-	-	-	-	3 dB	-	-

(A) The source impedance for all measurements shall be 600 ohms. All ports shall be terminated in appropriate loop or private line channel simulator circuits or 600 ohm terminations.

(B) These ports are for 2-wire on-premises station ports to separately registered terminal equipment.

(C) These through gain limitations are applicable to multiport systems where channels are not derived by time or frequency compression methods. Terminal equipment employing such compression techniques shall assure that equivalent compensation for through gain parameters is demonstrated in the registration application.

(D) Registered terminal equipment and registered protective circuitry may have net amplification exceeding the limitations of this subsection provided that, for each network interface type to be connected, the absolute signal power levels specified in this section are not exceeded.

(E) The indicated gain is in the direction that results when moving from the horizontal entry toward the vertical entry.

(F) Registered terminal equipment or protective circuitry with the capability for through transmission from voiceband private line channels or voiceband metallic channels to other telephone network interfaces shall ensure that the absolute signal power levels specified in this section, for each telephone network interface type to be connected, are not exceeded.

(G) Registered terminal equipment or protective circuitry with the capability for through transmission from voiceband private line channels or voiceband metallic private line channels to other telephone network interfaces shall assure, for each telephone network interface type to be connected, that signals with energy in the 2450 to 2750 Hz band are not through transmitted unless there is at least an equal amount of energy in the 800 to 2450 Hz band within 20 milliseconds of application of signal.

(ii) The insertion loss in through connection paths for any frequency in the 800 to 2450 Hz band shall not exceed the loss at any frequency in the 2450 to 2750 Hz band by more than 1 dB (maximum loss in the 800 to 2450 Hz band minus minimum loss in the 2450 to 2750 Hz band plus 1 dB).

(6) For tie trunk interfaces - Limitation on idle circuit stability parameters. For idle state operating conditions of registered terminal equipment and registered

protective circuitry, the following limitations shall be met:

(i) For the two-wire interface:

$$RL \geq \begin{cases} 9 - 3^{\frac{\log(f/200)}{\log(2.5)}} \ dB & ; \text{ for } 200 \text{ Hz} \leq f \leq 500 \text{ Hz} \\ 6 \ dB & ; \text{ for } 500 \text{ Hz} \leq f \leq 3200 \text{ Hz} \end{cases}$$

(ii) For the four-wire lossless interface:

$$tl_f \geq \begin{cases} 10 - 4^{\frac{\log(f/200)}{\log(2.5)}} \ dB & ; \text{ for } 200 \text{ Hz} \leq f \leq 500 \text{ Hz} \\ 6 \ dB & ; \text{ for } 500 \text{ Hz} \leq f \leq 3200 \text{ Hz} \end{cases}$$

$$tl_r > 40 \ dB$$

$$RL_r, RL_s \geq 3 \ dB$$

NOTE: The following definitions apply to return loss requirements:

RL — *the return loss of 2-wire terminal equipment at the interface with respect to 600 ohms + 2.16 μF (i.e., Z_{ref} = 600 ohms +2.16 μF).*

$$RL \geq 20 \log_{10} \left| \frac{Z_{PBX} + Z_{ref}}{Z_{PBX} - Z_{ref}} \right|$$

RL_i *the terminal equipment input (receive) port return loss with respect to 600* ohms (i.e., Z_{ref} = 600 ohms).

$$RL_i \triangleq 20 \log_{10} \left| \frac{Z_{PBX\ (input)} + Z_{ref}}{Z_{PBX\ (input)} - Z_{ref}} \right|$$

RL_o *the terminal equipment output (transmit) port return loss with respect to 600 ohms (i.e., Z_{ref} = 600 ohms)*

$$RL_o \triangleq 20 \log_{10} \left| \frac{Z_{PBX\ (output)} + Z_{ref}}{Z_{PBX\ (output)} - Z_{ref}} \right|$$

tl the transducer loss between the receive and transmit ports of the 4-wire PBX.

tl_f is the transducer loss in the forward direction from the receive port to the transmit port of the PBX.

$$tl_f \triangleq 20 \log_{10} \left| \frac{I_i}{I_r} \right|$$

where I_i is the current sent into the receive port and I_r is the current received at the transmit port terminated at 600 ohms.

tl_r is the transducer loss in the reverse direction, from the transmit port to the receive port of the PBX.

$$tl_r \triangleq 20 \log_{10} \left| \frac{I_i}{I_r} \right|$$

where I_i is the current sent into the transmit port and I_r is the current received at the receive port terminated at 600 ohms.
NOTE: The source impedance of I_i is 600 ohms

(7) Registered terminal equipment and registered protective circuitry shall provide the following range of dc conditions to off-premises station (OPS) lines.

(I) DC voltages applied to the OPS interface for supervisory purposes and during network control signaling shall meet the limits specified in § 68.306(a)(3)(I).

(ii) DC voltages applied to the OPS interface during the talking state shall meet the following requirements:

(A) The maximum open circuit voltage across the tip (T(OPS)) and ring (R(OPS)) leads for all classes shall not exceed 56.5 volts, and

(B) Except for class A OPS interfaces, the maximum dc current into a short circuit across tip (T(OPS)) and ring (R(OPS)) leads shall not exceed 140 mA.

(8) For connections to 1.544 Mbps digital services, the permissible code words for unequipped Mu-255 encoded subrate channels are limited to those corresponding to signals of either polarity, of magnitude equal to or less than X48, where code word, XN is derived by:

$$XN = (255 - N) \text{ base } 2$$
$$-XN = (127 - N) \text{ base } 2$$

(c) Signal power in the 3995-4005 Hz frequency band

(1) Power resulting from internal signal sources contained in registered protective circuitry and registered terminal equipment (voice and data), not intended for network control signaling. For all operating conditions of registered terminal equipment and registered protective circuitry that incorporate signal sources other than sources intended for network control signaling, the maximum power delivered by such sources in the 3995-4005 Hz band to an appropriate simulator circuit, shall be 18 dB below maximum permitted power specified in paragraph (b) of this section for the voiceband.

(2) Terminal equipment with provision of through-transmission from other equipment. The loss in any through-transmission path of registered terminal equipment and registered protective circuitry at any frequency in the 600 to 4000 Hz band shall not exceed, by more than 3 dB, the loss at any frequency in the 3995 to 4005 Hz band, when measured into an appropriate simulator circuit from a source that appears as 600 ohms across tip and ring.

(d) *Longitudinal voltage at frequencies below 4 kHz*. The weighted rms voltage* averaged over 100 milliseconds that is resultant of all of the component longitudinal voltages in the 100 Hz to 4 kHz band after weighting according to the transfer function of f/4000 where f is the frequency in Hertz, shall not exceed the maximum indicated under the conditions stated in para. (g) of this section.

Frequency range	Maximum Weighted rms Voltage	Impedance
100 Hz to 4 kHz	- 30 dBV	500 ohms

* NOTE: Average magnitudes may be used for signals that have peak-to-rms ratios of 20 dB and less. The rms limitations must be used instead of average values if the peak-to rms ratio of the interfering signal exceeds this value.

(e) *Voltage in the 4 kHz to 6 MHZ frequency range-general case - 2-wire and 4-wire lossless interface (except LADC)*. Except as noted, rms voltage as averaged over 100 milliseconds at the telephone connections of registered terminal equipment and registered protective circuitry in all of the possible 8 kHz bands within the indicated frequency range and under the conditions specified in para. (g) of this section shall not exceed the maximum indicated below. For paras. (1)(i) and (2)(i) of this section, "f" is the center frequency in kHz of each of the possible 8-kHz bands beginning at 8 kHz.

(1) *Metallic Voltage*

(i) *4 kHz to 270 kHz.*

Center Frequency (f) of 8 kHz Band	Max Voltage in all 8 kHz bands	Metallic Terminating Impedance
8 kHz to 12 khz	-(6.4 + 12 6 log f) dBV	300 ohms
12 kHz to 90 kHz	(23 - 40 log f) dBV	135 ohms
90 kHz to 266 kHz	-55 dBV	135 ohms

(2) *Longitudinal voltage*

(i) *4 kHz to 270 kHz.*

(ii) *270 kHz to 6 MHZ.* The rms value of the longitudinal voltage components in the frequency range of 270 kHz to 6 MHZ, shall not exceed -30 dBV. This limitation applies with a longitudinal termination having an impedance of 90 ohms.

Center Frequency (f) of 8kHz band	Max Voltage in all 8 kHz bands	Longitudinal Terminating Impedance
8 kHz to 12 kHz	-(18.4 + 20 log f) dBV	500 ohms
12 kHz to 42 kHz	(2 - 40 log f) dBV	90 ohms
42 kHz to 266 kHz	-62 dBV	90 ohms

(f) *LADC interface.* The metallic voltage shall comply with the general requirements in (1) below as well as the additional requirements specified in paras. (2) and (3) of this section. The requirements apply under the conditions specified in para. (g) of this section. Terminal equipment for which the magnitude of the source and/or terminating impedance exceeds 300 Ohms, at any frequency in the range of 100 kHz to 6 MHz, at which the signal (transmitted and/or received) has significant power, shall be deemed not to comply with these requirements. A signal is considered to have 'significant power' at a given frequency if that frequency is contained in a designated set of frequency bands that collectively have the property that the rms voltage of the signal components in those bands is at least 90% of the rms voltage of the total signal. The designated set of frequency bands must be used in testing all frequencies.

(1) *Metallic voltages - frequencies below 4 kHz.*

(i) *Weighted rms voltage in the 10 Hz to 4 kHz frequency band.* The weighted rms metallic voltage in the frequency band from 10 Hz to 4 kHz, averaged over 100 milliseconds that is the resultant of all the component metallic voltages in the band after weighting according to the transfer function of f/4000 where f is the frequency in Hertz, shall not exceed the maximum indicated below under the conditions stated in section (g).

Frequency range	Maximum voltage
10 Hz to 4 kHz	+3 dBV

(ii) *RMS Voltage in 100 Hz bands in the frequency range 0.7 kHz to 4 kHz.* The rms metallic voltage averaged over 100 milliseconds in the 100-Hz bands having center frequencies between 750 Hz and 3950 Hz shall not exceed the maximum indicated below.

Center frequency (f) of 100-Hz bands	Maximum voltage
750 to 3950 Hz	-6 dBV

(2) *Metallic Voltages - frequencies above 4 kHz - LADC interface.*

(i) *100-Hz bands over frequency range of 4 kHz to 270 kHz.* The rms voltage as averaged over 100 milliseconds in all possible 100-Hz bands between 4 kHz and 270 kHz for the indicated range of center frequencies and under the conditions specified in para. (g) of this section shall not exceed the maximum indicated below:

Center frequency (f) of 100-Hz bands	Maximum voltage in all 100-Hz bands
4.05 kHz to 4.60 kHz	0.5 dBV
4.60 kHz to 5.45 kHz	(59.2 - 90 log f) dBV
5.45 kHz to 59.12 kHz	(7.6 - 20 log f) dBV

Where f = center frequency in kHz of each of the possible 100 Hz bands.

(ii) *8-kHz bands over frequency range of 4 kHz to 270 kHz.* The rms voltage as averaged over 100 milliseconds in all of the possible 8-kHz bands between 4 kHz and 270 kHz for the indicated range of center frequencies and under the conditions specified in para. (g) of this section shall not exceed the maximum indicated below:

Center frequency (f) of 8-kHz bands	Maximum voltage in all 8-kHz bands
8 kHz to 120 kHz	(7.6 - 20 log f) dBV
120 kHz to 266 kHz	(59.2 - 40 log f) dBV